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UPDATED REPORT ON FENG YUN SATELLITE PROGRAM AND DEVELOPMENT

Executive summary

China Meteorological Administration (CMA) is operating FENGYUN (or FY for acronym) geostationary and polar-orbiting satellite systems. Currently, six FY satellites are on-orbit with well performance, including four geostationary meteorological satellites and two polar orbiting meteorological satellites. FY satellites take place in series. The odd number series are the polar-orbiting, while the even number series are the geostationary. The capital letter after the serial number refers to the seat of a particular satellite in the launching sequence.

The current operating LEO satellite system of CMA is the FY-3 series satellites flying on AM and PM orbits. The latest one, FY-3D, launched 15 Nov 2017, is in service since Jan 2019. Observational capability of FY-3D includes VIS, IR and MW imaging, IR and MW atmospheric sounding, greenhouse gas detection, radio occultation sounding, and space weather monitoring.

Four geostationary meteorological satellites operated by CMA are currently on-orbit, including three FY-2s and one FY-4. FY-2H is the latest one of FY-2 constellation. It is positioned at 79° especially for Indian ocean observation. FY-2F and FY-2G are positioned at 112°E and 99.5°E respectively. FY-2 satellites transmit 5-channel S-VISSR imagery. The second generation of GEO satellite of CMA is FY-4 series. The first unit of FY-4A was launched in 11 Dec, 2016. It has much enhanced capability in imaging, also designed to have sounding, lightning mapping, and space weather monitoring capabilities.

FY-3E, which is the first early-morning orbit satellite in China's polar-orbiting meteorological satellite family with 11 advanced remote sensing instruments, is scheduled to be launched in 2021. FY-4B, the first operational geostationary satellite in FY-4 series, is also planned to be launched in this year. The main observation capabilities are similar to those of FY-4A, with some significant performance improvements. Another highlight should be mentioned is the microwave GEO orbit program of FY-4 series will be confirmed in this year.

1 INTRODUCTION

The CMA FENGYUN Meteorological Satellite Program includes both geostationary and polar orbit satellite missions. FENGYUN satellites, or FY in acronym, take place in series. The odd number series is the polar-orbiting series, while the even number series is the geostationary. The capital letter after the serial number refers to the seat of a particular satellite in the launching sequence. Currently, 7 FY satellites are operational on-orbit, including 3 polar orbit satellites and 4 geostationary satellites. In the past year, no new FY Satellite launched. In 2021, CMA plans to launch two satellites, FY-3E and FY-4B. FY-3E is the first early morning orbit satellite in China's polar-orbiting meteorological satellite family. FY-4B is the first operational geostationary satellite in FY-4 series.

2 STATUS OF CURRENT SATELLITE SYSTEMS

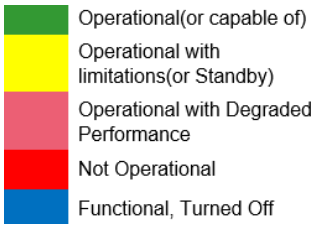
2.1 Status of Current GEO Satellite

The current operational FY-2 constellation consists of 3 satellites, namely FY-2H/G/F. FY-2H was the latest one. It is position at 79° especially for Indian Ocean observation. The second generation of GEO satellite of CMA is FY-4 series. Unlike FY-2, FY-4 is three-axes stabilized; and apart from inherited and much enhanced capability in imaging, it's also designed to have sounding, lightning mapping, and space weather monitoring capabilities. On 11 December, 2016, FY-4A was launched and positioned at 99.5 °E for in-orbit check out, then it moved to 104.7°E for primary operation.

Table 1 Current FENG YUN Geostationary Satellites (as of March 1, 2021)

Satellite (status)		Location	Launch date	EO instruments			
FY-2F	(L)	112 E	2012-1-13	S-VISSR			
FY-2G	(Op)	105 E	2014-12-31	S-VISSR			
FY-2H	(Op)	79 E	2018-06-05	S-VISSR			
FY-4A	(Op)	104.7 E	2016-12-11	AGRI	GIIRS	LMI	SEP

Op = Operational
P = Pre-operational
B = Back-up, secondary
L = Limited availability



2.1.1 Mission objectives, payload/instruments

The primary objectives of FY-2 program are as follows: 1) Continuously observing to obtain the earth imagery in visible, infrared, and water vapour spectral bands, from

which sea surface temperature, cloud parameters, and wind vectors can be derived; 2) Operating the Data Collection System (DCS) to collect and transmit data from domestic and overseas data collection platforms (DCPs); 3) Broadcasting data in HRIT/LRIT format, and 4) Monitoring space environment.
There are two main payload carried on FY-2. The detailed descriptions for each payload are as follows.
S-VISSR (Stretched Visible and Infrared Spin Scan Radiometer): The improved version for FY-2F/G/H had five VIS/IR channels (0.55-0.75μm, 3.5-4.0μm, 6.3-7.6μm, 10.3-11.3μm, and 11.5-12.5μm). The resolution is slightly improved from 5.76km (IR) and 1.44km (VIS), to 5.0km (IR) and 1.25 (VIS). The image cycle is 30 min.
SEM (Space Environment Monitor): A space particle monitor and an X-ray monitor are mounted on FY-2 to detect the space environment in proximity of the satellite, the solar activities and relevant space phenomenon. The SEM is transmitted via telemetry to the ground system.

FY-4 program is the successor of FY-2 program. The primary objectives of FY-4 program are as follows: 1) To take multiple spectral channel imagery of the earth with high temporal resolution; 2) To measure atmospheric vertical profile of temperature and humidity with improved vertical resolution and detection accuracy. 3) To detect and map positions of lightning events. 4) To monitor solar activities and space environments for space weather forecast service. 5) To collect data from data platforms and transmit to users. 6) To broadcast observational images, data and derived products with aboard transponder.
There are four main payload carried on FY4. The detailed descriptions for each payload are as follows.
AGRI (Advanced Geo. Radiation Imager): to fly on FY-4A/B/C, multi-spectral imager with two independent mirrors scanning north-south and east-west directions respectively; 216 sensors in 14 bands from visible to long-wave infrared (0.55～13.8 μm); on-board calibration for all bands, full optic length of radiation considered in calibration; resolutions：500m x1(ch), 1km x 2(ch), 2 km x 4(ch), 4km x7(ch); S/N: 90～200. NE△T: 0.2～0.7K@300K; full disk time＜15min.
GIIRS (Geo. Interferometric Infrared Sounder): to fly on FY-4A/B/C, two independent mirrors scanning north-south and east-west directions respectively; 32 x4 plane arrays for mid-wave (375 S/MIR channels) and long-wave infrared bands (538 LWIR channels); resolution: 16km; active and radiate coolers; radiometric calibration accuracy: 1K; spectral calibration accuracy: 10ppm; Mesoscale: 35 min (1000x1000km), China area: 67 min (5000x5000km).
LMI (Lightning Mapping Imager): to fly on FY-4A/C, two tubes for observation to achieve more spatial coverage; central wavelength: 777.4nm; S/N ≥ 6; spatial resolution: 7.8km; temporal resolution: 2ms.
SEP(Space Environment Package): to fly on FY-4A/B/C, a suite that contains a Magnetometer for 3-D magnetic field intensity, an Energetic Particle Detector detecting high-energy electron storms (1~165MeV, and >165MeV) and proton events (0.4~4MeV), and Space Weather Effect Detectors for the impact of space weathers on spacecraft.

2.1.2 Ground segment matters

The FY-2 ground segment consists of the Command and Data Acquisition Stations (CDAS); the Data Processing Centre (DPC), the Satellite Operation Control Centre (SOCC).

The ground segment of FY-4A consists 9 systems. They are DTS(Data acquisition & Tele-command System), MCS (Mission management and Control System), NRS Navigation & Registration System), CVS (Calibration and Validation System), PGS Product Generation System),DSS (Data Service System), CNS(Computer & Network System),SWAS S (pace Weather Application System), ASVS (Application Simulation Validation System).

Both FY-2 and FY-4 ground segment contains Ranging Stations (one primary station, three secondary stations including one back-up in Melbourne, Australia). The ground segment also includes the DCPs (Data Collection Platform), and HRIT/LRIT stations.

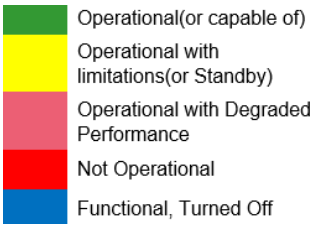
2.2 Status of Current LEO Satellite

The current operational LEO satellite system of CMA is the FY-3 series satellites flying on AM and PM orbits, including FY-3C/D. Some instruments on-board FY-3C were forced to suspend for the sake of the energy on the satellite platform. The relevant information of FY-3 is listed in table 2.

Table 2 Current FENG YUN LEO Satellites (as of March 1, 2021)

Satellite (status)		Launch date	EO instruments					
FY-3B	(L)	2010-11-05	MERSI	VIRR	IRAS	MWTS	MWHS	MWRI
			SBUS	TOU	ERM	SIM	SEM	
FY-3C	(B)	2013-09-23	MERSI	VIRR	IRAS	MWTS	MWHS	MWRI
			SBUS	TOU	ERM	SIM	SEM	GNOS
FY-3D	(Op)	2017-11-15	MERSI	HIRAS	MWTS	MWHS	MWRI	IPM
			GAS	WAI	SEM	GNOS		

Op = Operational
P = Pre-operational
B = Back-up, secondary
L = Limited availability



2.2.1 Mission objectives, payload/instruments

The FY-3 polar-orbiting satellite series is developed for LEO service from 2008 to 2021 or beyond. Basically, the FY-3 series are capable of global atmospheric sounding, IR/VIS/Microwave imaging, and atmospheric composition measurement, including O_3 amount, CO_2 amount et al. There is plan to develop the capability of precipitation sounding with radar for future missions.

The detailed descriptions for main instruments are as follows:

VIRR (Visible and Infra-Red Radiometer), flying on FY-3C, 10-channel VIS/IR radiometer for multi-purpose imagery, resolution 1.1 km, swath 2800 km.

MERSI (Medium Resolution Spectral Imager), flying on FY-3C/D, is a 20- channel radiometer (19 in VIS/NIR/SWIR + one TIR at 10.0-12.5μm) for ocean colour and vegetation indexes. Resolution 250m for 4 VIS/NIR and the TIR channel, 1 km for

other channels; swath 2800 km. Since FY-3D, the MERSI is evolved to MERSI-2, which has 25 channels (19 in VIS/NIR/SWIR + 6 TIR from 3.7.0-12.5μm).
MWRI (Micro-Wave Radiation Imager), flying on FY-3C/D , 6-frequencies/12 channels (all frequencies in double polarization) for multi-purpose MW imagery. Conical-scanning radiometer, resolution 9.5 x 15 km at 90 GHz, 30 x 50 km at 19GHz, swath 1400 km.
IRAS (Infra-Red Atmospheric Sounder), flying on FY-3C, 26-channel IR radiometer (including one VIS) for temperature/humidity sounding, resolution 17 km, swath 2250 km.
HIRAS-2 (High Spectral Infrared Atmospheric Sounder -II), flying on FY-3D, is a infrared sounding instruments with 2287 channels, nadir spatial resolution of 16 km, cross-track scanning model, mainly for numerical weather prediction and atmospheric composition detection.
MWTS-2 (Micro-Wave Temperature Sounder), flying on FY-3C/D, 13-channel MW radiometer for nearly-all-weather temperature sounding, 54 GHz band, resolution 70 km, cross-track scanning, swath 2200 km.
MWHS-2 (Micro-Wave Humidity Sounder), flying on FY-3C/D, 15 channel MW radiometer for nearly-all-weather humidity sounding. 183GHz band, resolution 15 km, cross-track scanning, swath 2700 km.
TOU/SBUS (Total Ozone Unit and Solar Backscatter Ultraviolet Sounder), flying on FY-3C, a suite of two UV spectro-radiometers, one (TOU) with 6 channels in the 308-360 nm range, resolution 50 km, swath 3000 km, for total ozone; the other one (SBUS) with 12 channels in the range 252-340 nm, resolution 200 km, nadir viewing, for ozone profile.
ERM (Earth Radiation Measurement), flying on FY-3C, 2 broad-band channel radiometer for earth reflected solar flux and earth emitted thermal flux over total (0.2-50μm) and short (0.2-4.3μm) waveband; resolution 28km, cross-track scanning with 2 degree NFOV, swath 2300 km, nadir viewing with 120 degree WFOV.
SIM (Solar Irradiance Monitor), flying on FY-3C, 3-channel radiometer over 0.2-50μm waveband for the total incident solar flux; viewing the Sun near the north pole area.
GNOS(GNSS Occultation Sounder), flying on FY-3D, receives signal from GPS or China BeiDou satellites; observing over 1000 occultation events per day.
GAS(Greenhouse gases Absorption Spectrometer), flying on FY-3D, has four narrow bands with center wavelength located at 0.76um, 1.6um, 2.1um and 2.3 um, which observes infrared light reflected from the earth's surface and the atmosphere. Column abundances of CO_2 and CH_4 are calculated from the observational data.
SEM (Space Environment Monitor), flying on FY-3C/D, is for in situ observation of charged particles in proximity of satellite.
WAI (Wide-field Auroral Imager), flying on FY-3D, is for remote sensing imaging the N2 Lyman-Birge-Hopfield (LBH) auroral bands.
IPM (Ionospheric PhotoMeter), flying on FY-3D, for nadir remote sensing the airglow intensity of the OI 135.6nm and N2 Lyman-Birge-Hopfield (LBH) bands.

2.2.2 Ground segment matters

CMA operates four ground stations to receive the FY polar orbiting satellite data. The ground stations are located in Beijing, Guangzhou, Urumuqi(including Kashgar sub-station), and Jiamusi. The received data are relayed to the Data Processing Center(DPC) through optical fiber link. The data is processed into various products, then disseminated, or archived.

NSMC uses 2 antennas at the North Pole Satellite Station of Esrange Space enter, Kiruna, Sweden to receive FY-3 satellites under contract between CMA and SSC(Sweden Space Company) for long-term on-orbit services of FY-3 and other polar satellite to be operated by NSMC. SSC receives downlinks of FY-3 at the Esrange Ground Station and transfers the data to the Beijing DPC. NSMC has rented TrollSat Station of Norway located near the South Pole to receive FY-3D data.

3 PRODUCTS AND SERVICES

3.1 Data Service

3.1.1 Archive Data Service

NSMC preserves data to the domestic and international user communities since 1983. The daily archive data volume is increasing rapidly at 0.5GB in 1987 and 10TB in 2020. By the end of 2020, NSMC has stored data volume up to 20PB from 45 satellites. FENGYUN series meteorological satellites data catalogue statistics which are sharing to global community shows in the table below.

Table 3 FENGYUN satellite data catalogue statistic

Satellite Series	Instruments (Groups)	Data Level	Data Catalogue
FY1	1	L1	1
		L2+Cloud and radiation	2
		L2+Ocean	1
		L2+Cryosphere	1
		L2+Land and ecology	1
FY2	1	L1	3
		L2+Atmosphere	6
		L2+Cloud and radiation	9
		L2+Ocean	1
		L2+Cryosphere	1
		L2+Land and ecology	1
FY3	17	L1	14
		L2+Atmosphere	11
		L2+Cloud and radiation	9
		L2+Ocean	2
		L2+Cryosphere	4
		L2+Land and ecology	11
FY4	3	L1	3
		L2+Atmosphere	12
		L2+Cloud and radiation	14
		L2+Ocean	1
		L2+Land and ecology	3

NSMC Data Centre is responsible to FENGYUN series satellite and the third party satellite data management and long term preservation, allows data download and assists domestic and international users with as much convenience as possible in their searching for meteorological and environmental satellite products.

The full FENGYUN satellite archive dataset is available on NSMC satellite data service website in English version (http://data.nsmc.org.cn). Users can search and download FENGYUN Satellite data after registration.
Over the past 16 years, more than 107 thousands users registered on the FENGYUN satellite data service website by the end of 2020. More than 8.5 PB satellites' data has been delivered to domestic and international users in 2020.

3.1.2 Rear Time Data Service

NSMC/CMA distributes real time FENGYUN meteorological satellite data for the high timeliness requirement users, FENGYUN satellite direct broadcast and CMACast.

Users in FENGYUN satellites direct broadcast service area with appropriate receiving equipment can directly receive real time data.

FY-2 DB: S-VISSR Data Transmission, compatible with MDUS acquisition stations, main features: frequency: 1687.5 MHz; bandwidth: 2.0 MHz; polarisation: linear-antenna diameter ～3m, G/T～12dB/K, data rate 660kbps.

FY-4 DB: FY-4 provides 1675 -1687 MHz HRIT, 1696-1698 MHz LRIT.

FY-3 DB:

- MPT, for full information transmission of MERSI measurement on FY-B/C. Main features: frequency: 7775MHz; bandwidth: 45 MHz; polarization: right hand circular; antenna diameter ～3 m, G/T～21.48dB/K, data rate 18.7 Mbps.
- AHRPT, for full information transmission of the instruments exclusive of the MERSI on FY-3B/C. Main features: Frequency: in the range 1704.5MHz; bandwidth: 6.8MHz; polarization: right hand circular. Antenna diameter ～3 m, G/T～6.8 dB/K, data rate: 4.2 Mbps.
- DPT, for dump data transmission. Frequency: 8146 MHz; bandwidth 149 MHz, data rate: 9.3 Mbps.

To support DB users to receive and process FY-3 transmission data, NSMC/CMA provides on http://satellite.nsmc.org.cn the Satellite to Ground Interface Control Document, pre-processing software packages for 7 instruments, namely MERSI, VIRR, MWTS, MWHS, MWRI, IRAS and GNOS.

The CMACast users can receive FENGYUN satellite data and product with DVB-S equipment in near real time. There are more than 2700 deployed CMACast receiving terminals, in which 22 overseas. Additional information of CMACast can be found on CMA WIS Portal (http://gisc.wis.cma.cn/wis/portal.pub).

3.1.3 Mobile Application Service

To increase the impact of FENGYUN series Satellites and help users obtain FENGYUN Satellite imagery, NSMC has launched 2 mobile applications on WeChat platform in 2018, FENGYUN Earth View for LEO satellites and FENG YUN Live for GEO satellites.

WeChat is one of the most popular instant messaging services in China and some overseas countries. By the end of 2020, WeChat had over 1.2 billion monthly active users from a wide range of age groups worldwide. WeChat Applet (mini-App, 'little program') is a special framework designed by Tencent that provides a light solution for using mobile application within the WeChat eco-system. It allows users to launch new Apps without download.

FENGYUN Earth View WeChat Applet release the latest 7 days global true color earth image captured by the MERSI-II instrument onboard FY-3D. The functions include: 1) Dragging and zooming in/out to view the full resolution global image; 2) Switching to the previous or next date; 3) Choosing interface between 3D mode and 2D mode. 4) Showing the location of current user.
FENGYUN Live WeChat Applet shows the time-series live cloud images taken by AGRI onboard FY-4A. Its functions include: 1) The most recent image of China region and full disk. 2) The videos of different regions in the latest 3/6/12/24/48/72 hours. This WeChat Applet can provide a convenient way for users to have a timely view of the live cloud imagery of FY-4A by using mobile phones. By the end of 2020, FENGYUN Live has accumulated 105,940 users.

3.2 User statistics

With the capability of multi-spectral global monitoring, and timeliness full disk quick observation, FENGYUN satellites were ready to serve global users, especially to 'Belt and Road'. By the year of 2020, many countries along 'Belt and Road' received FY satellite data by varies means. Real-time data users established different kinds of satellite data direct broadcasting systems, including 20 CMACast stations, 6 FY-2 DB stations, and 2 FY-3 DB stations. FY-3 pre-processing software packages have been free shared and installed in 25 countries. 29 countries registered as a member of FY_ESM. In 2020, CMA initiated 14 times emergency services for other countries, including dam break, tropical cyclone, flash flood, etc (Table 4). The FY satellite data centre website users have expended to 115 counties including more than 80 Belt and Road countries. FENGYUN satellites have been incorporated into the global operational application meteorological satellite series by the World Meteorological Organization (WMO). NSMC also was cooperating with CGMS, CEOS, CSPP, EUMETSAT, NOAA, APSCO and other foreign satellite agencies and organizations. Besides that, CMA strengthened cooperation with regional and "Belt and Road" countries by enhance FENGYUN satellites service capabilities. CMA signed agreement with the National Institute of Meteorology of Mozambique (INAM), the Ministry of Emergency Situations of the Kyrgyz Republic (MES KR), and the Civil Aviation of the Sultanate of Oman Represented by the Directorate General of Meteorology (DGMet) in 2019. Those agreements aimed to improving the application of FENGYUN meteorological satellite data and enhancing the capacity in weather forecasting, disaster warning, and disaster prevention and mitigation service are of great significance to protecting the safety and well-being of the peoples of the two countries and the national economic development as well as to promoting regional cooperation.

Table 4. Emergency services with Fengyun satellite in 2020

Date	Country	Disaster	From
4/5/2020	Uzbekistan	Dam break	FY_ESM/China-

			GEOSS
6/5/2020	Guatemala	Wildfire	FY_ESM/CHARTER
19/5/2020	Bangladesh	Tropical cyclone	FY_ESM
4/7/2020	Myanmar	Dam break	FY_ESM
8/7/2020	Nepal	Flash flood	FY_ESM/CHARTER
9/9/2020	Russia	Flash flood	CHARTER
13/10/2020	Togo	Flash flood	CHARTER
15/11/2020	the Philippines	Tropical cyclone	CHARTER
18/11/2020	Columbia	Tropical cyclone	CHARTER
3/12/2020	Sri Lanka	Tropical cyclone	FY_ESM/CHARTER

4 FUTURE SATELLITE SYSTEMS

China's meteorological satellite and its application development plan (from 2021 to 2035) has been submitted to the government and are under evaluation and consultation now. In the plan, there are four FY-3 polar-orbiting satellites to be launched, which will be arranged by the layout of three solar synchronous polar-orbiting satellites in early-morning, mid-morning and afternoon, and one precipitation measurement satellite in inclination orbit by 2025. Meanwhile, there are three more FY-4 geostationary satellites to be launched, including two optical GEO satellites and one microwave GEO satellite. The operational pattern of the FY-4 geostationary meteorological satellites "dual-satellite operation and in-orbit backup" will be established.

According this plan, up to 2035, China's third-generation polar-orbiting meteorological satellites system FY-5 will be initially implemented, and the first satellite of the third-generation geostationary meteorological satellites system FY-6 will also be launched.

4.1 Fengyun Satellite Projects by 2025

4.1.1 FY-3 polar-orbiting Satellites by 2025

The third batch of FY-3 satellites program, which is including four satellites FY-3E/F/G/H, has been approved and scheduled to be launched in the next three years.

FY-3E, which is the first early-morning orbit satellite in China's polar-orbiting meteorological satellite family, is scheduled to be launched in 2021. Its local time at descending node is 5:30 AM. It is equipped with 11 advanced remote sensing instruments of MERSI-LL for low-light level, the HIRAS-II, the GNOS-II, the MWTS-III, the MWHS-II, the SIM-II, the Solar Spectral Irradiance Monitor (SSIM), the Wind Radar, the SEM-II, the Triple-angle Ionospheric Photometer (Tri-IPM) and the Solar X-ray and Extreme Ultraviolet Imager (X-EUVI). FY-3E will focus on the application of Numerical Weather Prediction (NWP), as well as ensuring the global imaging observation and atmospheric vertical sounding measurement.

FY-3F is a mid-morning orbit satellite with descending equatorial crossing time 10:00 AM. It's scheduled to be launched in 2022. There are 10 remote sensing instruments on it including MERSI-III, MWTS-III, MWHS-II, MWRI-II, GNOS-II, HIRAS-II, Ozone Measurement Suite -Nadir (OMS-N), Ozone Measurement Suite -Limb (OMS-L), the

ERM-II and SIM-II. FY-3F will focus on the observation of the Earth's surface imaging, which is mainly applied to weather forecasting, ecological environment monitoring, meteorological disaster monitoring and research.
FY-3G, which is an inclined low earth orbit satellite mainly used for precipitation measurement, is scheduled to be launched in 2022. There are 4 remote sensing instruments on it including MERSI-RM (simplified form), MWRI-RM (for precipitation), GNOS-II, and the Precipitation Measuring Radar (PMR). FY-3G is mainly used for monitoring of heavy rainfall in severe weather system, providing three-dimensional structure information of precipitation in the middle and low latitudes of the world, and support improving the accuracy of precipitation meteorological forecast.
FY-3H, which is the last one in the third batch of FY-3 satellites program, is an afternoon orbit satellite, scheduled to be launched in 2023. Its local time at ascending node is 14:00 PM. There are 9 remote sensing instruments on FY-3H, which are MERSI-III, MWTS-III, MWHS-II, MWRI-II, GNOS-II, HIRAS-II, GAS-II, WAI-II, and IPM. The main objectives of FY-3H are the quantitative detection of atmospheric composition and the monitoring of climate change. Its data can be used for weather forecasting, atmospheric chemistry and climate change monitoring and research.
The fully networked FY-3 operational satellites will have integrated observation capabilities, such as high temporal and spatial resolution global optical imaging observation capability, high precision optical and microwave combination of atmospheric temperature and humidity vertical distribution detection capability, GHG measurement capability, wind field and precipitation measurement capabilities with active remote sensing instruments, and the solar and space environment monitoring capabilities.

4.1.2 FY-4 geostationary Satellites by 2025

FY-4B and FY-4C in the second batch of FY-4, are scheduled be launched in 2021 and 2025 separately to ensure the continuity, reliability and stability of the observation service of geostationary meteorological satellites.
FY-4B, which is the first operational geostationary satellite in FY-4 series, is scheduled to be launched in 2021. The main observation capabilities are similar to those of FY-4A, with some significant performance improvements. It will be probably positioned at a 123.5°E to continue operations as a main operational geostationary meteorological satellite. The remote sensing instruments on FY-4B are the AGRI, the GIIRS, the Geostationary High Speed Imager (GHI), and the SEP.
Compared with the previous two satellites FY-4A and FY-4B, the capability of FY-4C will get great improvements. The space weather monitoring capability of FY-4C has been further enhanced with the addition of some space weather observation instruments. The located position will be determined according to the technical status and other factors at that time. The remote sensing instruments are including AGRI, GIIRS, LMI, SEP, the Multiband Ionospheric Ultra-Violet Spectrum Imager (MUSI), the Solar Extreme-Ultraviolet Imager (SUVI), and the Solar X-EUV Irradiance Sensor (SXUS).
The first satellite of FY-4 MW series is planned to be launched in 2024. The main payload is the microwave sounder, which can perform full-disk observation and regional observation.

FY-4 series satellites represent an improved and new capability of the Chinese geostationary weather satellite system. With advanced imaging and sounding instruments on FY-4 series providing high temporal, spatial, and spectral resolution measurements, the benefit is expected to be large for severe weather monitoring,

warning, and forecasting. The lightning information is expected to significantly improve warnings of severe storm hazards, convection precipitation, and lightning strikes. Assimilation of data and derived products from the AGRI, GIIRS, and LMI in both global and regional NWP models is expected to show valuable improvement in forecast skill. FY-4 series will also enhance the capabilities of space weather monitoring and warning.

4.2 Vision for China's Meteorological Satellites in 2035

Consistent with the WMO Integrated Global Observing System (WIGOS) in 2040 for the space-based observing system component, an integrated observing system of Fengyun weather and climate satellites will be established by 2035, which is a backbone system with specified orbital configuration and measurement approaches, composed of FY-5 polar-orbiting and FY-6 geostationary meteorological satellites. The established FY-5 satellites system will fill in the blanks of space-based profiling of global wind as atmospheric dynamical fields, climatic variables, fill in the gaps of spatial and temporal coverage by optimizing the constellation configuration, promote space/ground co-observing capability to better meet the requirements for emergency response to meteorological disasters. FY-6, the third generation geostationary meteorological satellites, will enable the integrated observation capability of FY satellites to reach the world's leading level. The Radiometric Benchmark Satellite mission aiming to establish stable and traceable space calibration reference will be developed as well.

Meanwhile, a backbone system with open orbit configuration and flexibility to optimize the implementation will be developed, which is composed of some small/ large satellites programmes for dedicated-objective mission with the capabilities of higher temporal and spatial resolution and fast sampling, global cloud, aerosol, wind etc. dedicated observation, to meet the requirements of weather forecasting, meteorological risk reduction and emergency response promotion. Furthermore, the operational pathfinders, technology and science demonstrators will be explored to respond to R&D needs.

Fig.1 Layout of Fengyun Satellites in 2035